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A study of some anatomical characters of North American Gramineæ. II.

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The genus Uniola.

(WITH PLATES XXI AND XXII.)

Uniola gracilis Michx., *U. nitida* Baldw., *U. paniculata* L. and *U. Palmeri* Vasey.—These four species form together two groups, the first two on the one and the last two on the other side, on account of differences in the anatomical structure of their leaves. It was also to be supposed so, since they inhabit localities so very different. The first group occurs in the woods or swamps, while the second one grows on the sand hills on the sea shore. We shall now see how they differ from each other and from the species described in the preceding part of this paper, U. latifolia, an inhabitant of shaded slopes.

Epidermis.—The epidermis in U. gracilis and U. nitida agrees in most respects with that of U. latifolia, and the only essential difference consists in the presence or absence of long hairs and thorn-shaped expansions; U. gracilis shows the presence of both organs on the superior face of the blade, but in smaller number than observed in U. latifolia. In U. nitida these organs are entirely wanting.

The cells of epidermis which cover the stereome on the inferior face are strongly thickened and laminated in U. gracilis and U. nitida (plate XXII, fig. 6), which shows a difference from what we have seen in U. latifolia. The bulliform cells and the stomates show, however, nearly the same structure and distribution. But in U. paniculata and U. Palmeri the epidermis is entirely different; the cells on both faces are strongly thick-walled and porose (plate XXII, fig. 10), rectangular or quadrangular, and arranged so that there is either one short cell between two long ones, as in U. Palmeri, or even three short between two long ones, as has been observed in U. paniculata.

No hairs are present in these two species, but numerous sharply pointed and porose spines (plate XXII, figs. 11–12) proceed from the superior face of the leaf of U. paniculata,

while in U. Palmeri the epidermal expansions are merely represented by wart-shaped, obtuse organs. The epidermis of the inferior face is on the contrary entirely smooth in these two species.

Stomates are present on both faces, but especially on the margins of the deep sinuses of the superior face, in the strata which border on the bulliform cells; these stomates show in U. paniculata the normal aspect, but in U. Palmeri they are slightly depressed below the general surface (plate XXII, fig. 14), and surmounted by wart-shaped expansions from the epidermis in groups of as many as seven. The bulliform cells of U. gracilis and U. nitida agree very well with those described for U. latifolia; in U. paniculata and U. Palmeri they form only very small groups, but are here in contact with a large mass of uncolored parenchyma.

Mestome-bundles.—The arrangement of these is easily to be seen, if the sections figured in the accompanying plates are examined. Plate XXI, fig. 1 shows a section of the median part of the blade of U. gracilis; plate XXII, fig. 7, a similar section of U. nitida; fig. 8 of U. paniculata; and fig. 13 of the female plant of U. Palmeri. It must be remarked here that the anatomical structure of the leaf of the male and female plant of U. Palmeri is identical.

The carene in U. gracilis and U. nitida is occupied with but a single mestome-bundle, whereas there were several in U. latifolia. In U. paniculata and U. Palmeri there is no carene and the median nerve is not different in any respect from the largest ones in the whole blade. Furthermore there are no mestome-bundles between the groups of bulliform cells and the epidermis of the inferior face, as was the case in U. latifolia.

The minute structure of the mestome-bundles in U. gracilis and U. nitida is the same. There is a thin-walled parenchyma-sheath around the entire bundle, uncolored in the midrib or partly green in the other ribs. Sometimes, as for instance in the large bundles excepting the median one, the parenchyma-sheath has a few thick-walled cells, where it is in contact with the stereome. But besides this, the proper sheath is also to be seen and inside this another one, which consists of very thick-walled cells, forming in the largest bundles, those of first degree, a closed sheath around the leptome and the hadrome. This inner sheath is also present in the smaller bundles, but is here more or less interrupted

(plate XXI, fig. 4). In U. latifolia there is present a thick-walled parenchymatic tissue between the leptome and hadrome, and the same is also to be observed in U. gracilis and U. nitida, at least in the largest bundles. But neither this stratum nor the inner sheath of thick-walled cells may be considered as indicating any mestome-sheath; they merely represent a mestome-parenchyma for the same reason as mentioned for U. latifolia.

The mestome-bundles show, as in U. latifolia, three different forms depending on their strength and development. Those of the first degree have a closed inner sheath besides a layer of similar thick-walled cells between the leptome and hadrome, while in those of the second degree the leptome and hadrome are in contact with each other. In the smallest bundles there is no closed inner sheath of thick-walled cells, but merely an interrupted layer on the leptome side, and the leptome and hadrome are in immediate contact with each other. The leptome and hadrome, considered by themselves, show the strongest development in the largest bundles, those of the first degree.

As to the distribution of these different forms of mestome-bundles in the entire blade, I do not dare try to give any formula, as has been done in U. latifolia. There seem to be too many variations, especially on comparing leaves of specimens from different localities, but it may be said with good reason that the bundles of the second degree are the most numerous in the whole blade, while the largest ones are present in a relatively small number.

On examining the mestome-bundles in U. paniculata and U. Palmeri, there will be seen a rather important difference in structure from what has been shown above. The proper parenchyma-sheath is thin-walled in both species, but contains large deposits of starch in U. paniculata (plate XXII, fig. 9) and forms a border between the entire mestome-bundle and the mesophyll on both sides. In U. Palmeri (plate XXII, fig. 5) on the contrary it does not contain starch and forms an annular sheath around the whole bundle, not extending to the epidermis on either of the two faces.

There is in the largest bundles of U. paniculata a closed sheath of thick-walled parenchyma around the leptome, while in U. Palmeri both the leptome and hadrome are surrounded by a similar sheath, besides which the leptome contains several groups, more or less isolated, of very thick-walled cells.

Although not strictly belonging to the mestome-bundles, it may be mentioned here, that there is in the U. paniculata a quite considerable tissue of large-celled parenchyma between the hadrome and the stereome of the superior face, and this parenchyma contains starch, like the surrounding sheath.

We shall also find in these two species a certain difference as to the development of the mestome-bundles, as described for the preceding species. U. paniculata shows two degrees, the first one as described above; the second is on the contrary characterized by having the leptome and hadrome in contact with each other. U. Palmeri shows, besides the form of the first degree described above, a second one, in which the inner sheath is reduced to a horse-shoe shaped layer on the leptome side, besides a few thick-walled cells between the leptome and hadrome but none in the leptome itself.

These layers of thick-walled cells in the mestome-bundles of U. paniculata and U. Palmeri, whether they form a closed sheath or not, are identical with those mentioned for the preceding three species, as representing a mestome-parenchyma; the same is the case with the groups of similar cells, which we have seen in the leptome of U. Palmeri. Concerning the distribution of these different mestome-bundles in the U. paniculata and U. Palmeri, those of the second degree are the most numerous, but no rule can be given as to their situation between the larger ones.

The stereome.—This forms in U. gracilis and U. nitida two groups, one above and one below each mestome-bundle, and shows only very small differences. In U. gracilis the stereome of the superior face of the carene is widely separated from the mestome-bundle by a large tissue of uncolored parenchyma, while in U. nitida it borders immediately on the parenchyma-sheath. It forms as in U. latifolia a nearly triangular group on each margin of the blade. Nearly the same arrangement is found in U. paniculata, in which there is one group above and below each mestome-bundle. In this the stereome of the superior face is widely separated from the mestome-bundle by the parenchyma, which has been described above. Small groups of stereome are also to be observed inside the proper parenchyma-sheath of this species (plate XXII, fig. 9); it seems as if these thick-walled cells belong to this element, the stereome, rather than to the hadrome.

Finally U. paniculata shows groups of stereome opposite the bulliform cells, separated from these by an uncolored tis-

sue of parenchyma. U. Palmeri has not these last mentioned stereome-groups opposite the bulliform cells, but merely one above and one below each mestome-bundle, both of them bordering on the parenchyma-sheath.

Besides these groups of stereome, there is also one large group on each of the two margins of the blade of both U. paniculata and U. Palmeri.

The mesophyll.—This tissue is most extensive in U. gracilis and U. nitida, where it forms broad layers of rather large cells between the mestome-bundles and is in contact with epidermis on both faces. It is relatively but sparingly represented in the two other species, and is here not only separated by the mestome-bundles with their corresponding groups of stereome, but also by the broad layers of uncolored parenchyma. Thus there is one two isolated group of mesophyll on each side of the mestome-bundles. The cells of this tissue are, in U. paniculata and U. Palmeri, rectangular, very narrow and thin-walled.

The uncolored parenchyma.—This is very distinct in the carene of U. gracilis (plate XXI, fig. 2), where it occupies a large space between the mestome-bundle and the superior epidermis. There is also in this same species a single stratum of uncolored cells outside the parenchyma-sheath of the two mestome-bundles next to the midrib and bordering on the carene (plate XXI, fig. 1). This parenchyma is also present and relatively much more abundant in U. paniculata and U. Palmeri, where it forms large groups between the bulliform cells and the epidermis of the inferior face.

From the foregoing it will be seen that these five species of the genus Uniola show several anatomical characters in their leaf-structure by which they may easily be distinguished. These characters may be summarized as follows:

Epidermis.

Large cells in alternation with small ones	U. paniculata. U. Palmeri.
Long hairs on the superior face	U. latifolia. U. gracilis.
Thorn-shaped expansions on the superior face	U. latifolia. U. gracilis. U. paniculata.
Wart-shaped expansions on the superior face	U. Palmeri.
Bulliform cells forming large groups	U. latifolia. U. gracilis. U. nitida.

Bulliform cells forming smaller groups	U. paniculata. U. Palmeri.
Stomates depressed, surmounted by epidermal expansions	U. Palmeri.

Mestome-bundles.

One buudle between each group of bulliform cells and the inferior epidermis	U. latifolia.
Leptome and hadrome surrounded by a sheath of thick-walled parenchyma in the large bundles	U. gracilis. U. nitida. U. Palmeri.
Only the leptome surrounded by thick-walled cells	U. latifolia. U. paniculata.
Groups of thick-walled parenchyma in the leptome	U. Palmeri.
Parenchyma-sheath containing starch, extending from the superior to the inferior epidermis, not forming any annular sheath around the bundle	U. paniculata.

Mesophyll.

Separated by groups of uncolored parenchyma	U. paniculata. U. Palmeri.

Stereome.

Six isolated groups on the superior face of the carene	U. latifolia.
One group opposite the bulliform cells	U. paniculata.
Isolated groups inside the parenchyma-sheath	U. paniculata.

Uncolored parenchyma.

One large group in the carene	U. latifolia. U. gracilis.
One group between the mestome bundles	U. paniculata. U. Palmeri.

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Explanation of Plates.

Plate XXI.—Figs. 1–4. *Uniola gracilis.*—Fig. 1. Transverse section of leaf. × 37.—Fig. 2. Transverse section of the median part of the leaf, the carene; the inferior face of the leaf at *I.* × 160.—Figs. 3 and 4. Transverse sections of two small mestome-bundles. Fig. 3 shows a closed sheath of thick-walled parenchyma-cells inside the proper parenchyma-sheath *P*. *L*, the leptome: *S*, the stereome on the inferior face of the leaf. In fig. 4 the inner sheath is not complete, but merely represented by two groups of thick-walled cells. × 200.

Fig. 5. *U. Palmeri.* Transverse section of a large mestome-bundle. On the left side in the figure are the bulliform cells to be seen at *B*, *C*, and the mesophyll at *M*. Several thick-walled parenchyma cells are to be observed in the leptome and there is a closed sheath of similar cells inside the proper parenchyma-sheath *P*. × 320.

Plate XXII.—Fig. 6. *U. gracilis.* Epidermis, taken from the carene, transverse section. × 560.

Fig. 7. *U. nitida.* Transverse section of leaf; the inferior face at *I*. × 74.

Figs. 8–12. *U. paniculata.*—Fig. 8. Transverse section of leaf; the inferior face at *I*. × 60. Fig. 9. Transverse section of a large mestome-bundle. The proper parenchyma-sheath, *P*, contains starch, figured in a few of the cells, as

does also the large parenchyma cells between the mestome and the stereome of the superior face. The leptome is enclosed by layers of very narrow cells and separated from the hadrome. × 240. Fig. 10. Epidermis of the inferior face. × 560. Figs. 11 and 12. Thorn-shaped expansions from the superior epidermis, seen from the side and from above. × 240.

Figs. 13 and 14. *U. Palmeri.*—Fig. 13. Transverse section of leaf. × 74. Fig. 14. Stomate from the inferior face, transverse section. × 320.

Notes on Uredineæ.

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Puccinia Stipæ is variously cited by different writers. Dietel[1] writes *P. Stipæ* Opiz, and considers the American form, heretofore called *P. Stipæ* Arthur, identical with it. In Sydow's Uredineen, fascicle I, No. 28, it is given as *P. Stipæ* (Opiz) Hora, and is so spoken of by Magnus[2] in a notice of the publication.

Opiz[3] made use of the name in a list of Bohemian plants, in which no characterizations or notes of any kind are given. It was not used as a specific name, but for a sub-form of a variety of P. Graminis. The full name reads *Puccinia Graminis* Pers., c *foliorum* Opiz, *β Stipæ* Opiz. The host is not mentioned, but it was presumably a Stipa, and quite possibly S. capillata, on which the rust was gathered in 1888 by Paul Hora in the region covered by Opiz's list. Whether a description of the species has been published by Hora or not the writer does not know, but if so it probably did not antedate the publication in America.[4] The name correctly written would therefore be *Puccinia Stipæ* (Opiz) Arthur.

Puccinia ornata was first published as the name of a Leptopuccinia on Rumex [5] in 1887, and consequently the later application of the specific name to another Puccinia by Harkness[6] calls for correction. It would be a pleasure to dedicate this interesting form to the discoverer, if another

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[1] Hedwigia, xxviii, (1889, p. 187).
[2] Hedwigia, xxviii, (1889, p. 94).
[3] Seznam Rostlin Kvetêny Ceské, 1852, p. 138.
[4] Arthur, Preliminary List of Iowa Uredineæ, in Bull. Iowa Agric. Coll., Nov. 1884, p. 160.
[5] Report of botanical work in Minnesota, in Bull. No. 3, Geol. Surv. Minn., 1887, p. 30.
[6] Proc. Cal. Acad. Sci., 2nd. Ser., ii. 1889.